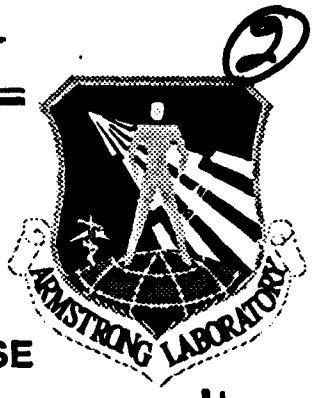
AL/CF-TP-1994-0004



THE INFLUENCE OF CORONARY ARTERY DISEASE ON +G_z TOLERANCE: A PRELIMINARY STUDY

John W. Burns

CREW SYSTEMS DIRECTORATE
CREW TECHNOLOGY DIVISION
2504 D Drive, Suite 1
Brooks Air Force Base, TX 78235-5104

Jemett L. Robinson

Rothe Development, Incorporated
4614 Sinclair Road
San Antonio, TX 78222

John W. Fanton, Lt Col, USAF, BSC, DVM
Harold Davis, Lt Col, USAF, BSC, DVM

OCCUPATIONAL AND ENVIRONMENTAL HEALTH DIRECTORATE
2402 E Drive
Brooks Air Force Base, TX 78235-5114

Londe A. Richardson, Lt Col, USAF, MC, FS

AEROSPACE MEDICINE DIRECTORATE
2507 Kennedy Circle
Brooks Air Force Base, TX 78235-5117

April 1994

Final Technical Paper for Period February 1989 – December 1991

AIR FORCE MATERIEL COMMAND
BROOKS AIR FORCE BASE, TEXAS

ARMSTRONG LABORATORY

NOTICES

When Government drawings, specifications, or other data are used for any purpose other than in connection with a definitely Government-related procurement, the United States Government incurs no responsibility or any obligation whatsoever. The fact that the Government may have formulated or in any way supplied the said drawings, specifications, or other data, is not to be regarded by implication, or otherwise in any manner construed, as licensing the holder or any other person or corporation; or as conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

The animals involved in this study were procured, maintained, and used in accordance with the Animal Welfare Act and the "Guide for the Care and Use of Laboratory Animals" prepared by the Institute of Laboratory Animal Resources - National Research Council.

The Office of Public Affairs has reviewed this report, and it is releasable to the National Technical Information Service, where it will be available to the general public, including foreign nationals.

This report has been reviewed and is approved for publication.

JOHN W. BURNS, Ph.D.
Acting Chief, Flight Motion Effects Branch

RONALD C. HILL, Colonel, USAF, BSC
Acting Chief, Crew Technology Div

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	April 1994	Final – February 1989 – December 1991

4. TITLE AND SUBTITLE
The Influence of Coronary Artery Disease on +G_z Tolerance: A Preliminary Study

5. FUNDING NUMBERS
C – F33615-85-D-4510
PE – 61101F
PR – 7930
TA – 14
WU – 8F

6. AUTHOR(S)
John W. Burns
Harold Davis
Jemett L. Robinson
Londe A. Richardson
John W. Fanton

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Rothe Development, Incorporated
4614 Sinclair Road
San Antonio, TX 78222

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAMES(S) AND ADDRESS(ES)
Armstrong Laboratory (AFMC)
Crew Systems Directorate
Crew Technology Division
2504 D Drive, Suite 1
Brooks Air Force Base, TX 78235-5104

10. SPONSORING/MONITORING AGENCY REPORT NUMBER
AL/CF-TP-1994-0004

11. SUPPLEMENTARY NOTES
Armstrong Laboratory Technical Monitor: Dr. John W. Burns, (210) 536-3521.

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)

Current Air Force policy restricts pilots, with even minimal coronary artery disease (CAD), from flying high-performance aircraft. Liberalization of this policy is being considered, but additional data are needed for a more informed decision. Eleven miniature swine (MS) were placed on a high cholesterol/high fat diet for 1 year. Five additional MS were maintained on a standard control swine diet (no cholesterol) over the same time. A vascular access port (VAP) was surgically placed into the superior vena cava. The 16 unanesthetized MS were +G_z-stressed one or two times each, using an alternating 4-8 +G_z simulated aerial combat maneuver (SACM) with 10 sec at each +G_z level. The MS were protected with an abdominal bladder anti-G suit. At the end of the SACM, Tc-99m was infused into the VAP and the MS were scanned for myocardial perfusion approximately 1 h later. Three MS died before data collection, one at 6 mos and two at 9 mos. Histopathology showed moderate-to-severe CAD in the three MS. Control and experimental plasma cholesterol levels (mg%) were: total = 77 and 422; ratio = 2.3 and 8.6; LDL = 35 and 353, respectively. Dysrhythmias and T-wave alterations during +G_z were seen equally in both the control and experimental MS. However, ST-T segment changes during +G_z were observed in all of the cholesterol MS, but not in the control MS. Coronary histopathology showed normal vessels from the control MS and stenoses ranging from 0-95% from the cholesterol MS. There was a positive relationship between ST-T changes and abnormal myocardial perfusion scans. Additional MS studies are planned to identify the severity of CAD at the earliest detectable indication of ischemia during +G_z and treadmill stress.

14. SUBJECT TERMS
Coronary artery disease
ECG
High cholesterol diet
Histopathology
Miniature swine
TC-99m scan

15. NUMBER OF PAGES
10

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	UL

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. Z39-18
298-102

INTRODUCTION

Current Air Force policy restricts pilots, with even minimal coronary artery disease (CAD), from flying high-performance aircraft. Liberalization of this policy is being considered; however, additional data are needed for a more informed decision. The objective of this study was: Determine if minimal CAD results in measurable ischemia or cardiac dysfunction in $+G_z$-stressed miniature swine (MS); if not, determine the level of CAD where ischemia occurs.

METHODS

Sixteen female MS with an average weight of 32.5±1.6 Kg were used in this study. Baseline coronary angiograms were performed on all of the MS to define any preexisting CAD or coronary abnormalities. Eleven of the MS were placed on a high cholesterol/high fat diet (1.5% cholesterol and 15% beef tallow) for 1 year. The remaining five control MS were maintained on a standard laboratory swine diet (no cholesterol) over the same time period.

A vascular access port (VAP) for blood sampling and isotope injection was placed into the superior vena cava through the external jugular vein, and brought subcutaneously to the neck behind the ear. The animals were sampled monthly for serum cholesterol (total, LDL, HDL, ratio, and triglycerides) and weighed.

The 16 MS were $+G_z$-stressed using an alternating 4-8 $+G_z$ simulated aerial combat maneuver (SACM) profile (10 sec at each $+G_z$ level). Continuous

ECG monitoring during $+G_z$ used a 10-lead chest and limb system. The MS were protected with an abdominal bladder anti-G suit. Tc-99m labeled Cardiolite (DuPont) was injected into the VAP during the last 10 sec of the SACM profile; the MS were scanned for myocardial perfusion approximately 1 h following $+G_z$ using SPECT imaging techniques. An attempt was made to subject each animal to $+G_z$-stress at least twice for reproducibility.

At necropsy, the MS were anesthetized with sodium pentobarbital and the heart was retrograde perfused through a cannula placed in the aorta. The perfusion was initiated with a 5% dextrose solution, followed by buffered glutaraldehyde when the effluent from the heart became clear. After soaking the heart in formaldehyde, the coronary arteries were sampled by taking approximately 5-mm sections, with surrounding tissue, at a number of locations along the left circumflex, left anterior descending (LAD), right, and the posterior descending coronary arteries. The papillary muscles, as well as other areas of the myocardium were also investigated for evidence of CAD. Other tissue studied were: aorta, pulmonary artery, left atrium, right atrium, lung, liver, and kidneys. The coronary artery tissues were observed histologically for evidence of CAD and percent cross sectional stenosis. The other tissues were investigated for pathologic change related to the diet.

RESULTS

Three of the MS died before centrifuge data collection; one died at 6 months and two died at 9 months. Histopathology showed moderate-to-severe CAD in the three MS.

There were no significant differences in heart rate (HR) between the control and cholesterol MS during the 1st $+G_z$ exposure. However, there was a significant ($p<.003$) decrease in HR at 1 min post $+G_z$ during the 2nd exposure of the control MS, compared to the cholesterol MS.

Dysrhythmias, such as sinus tachycardia (ST), PVCs, sinus bradycardia (SB), and ventricular tachycardia (VT), as well as T wave and P wave changes and axis shift were observed equally in both control and cholesterol MS during all $+G_z$ exposures.

None of the control MS had ST segment elevation during any of the $+G_z$ exposures. Moreover, there was no stenosis found in any of the control MS. ST segment elevation of up to 4 mm was seen in leads II, III, aVF, V5 or V6 of the cholesterol MS. Seven of seven cholesterol MS exhibited ST segment elevation during their 1st $+G_z$ exposure, associated with abnormal Tc-99m scans in 5 of 6 of those MS; whereas ST elevation was observed in 3 of 4 MS during the 2nd exposure and 2 of those 4 MS showed abnormal Tc-99m scans. Single site stenosis in the cholesterol MS ranged from 0% to 95% in the proximal, mid, and distal regions of the left circumflex, LAD, right, and posterior descending coronary arteries, with aggregate stenosis over the whole heart ranging from 0% to 800%.

Septal, lateral, and posterior left ventricular wall ischemia were observed using the Tc-99m perfusion scans. Apical ischemia was masked by apical thinning, seen in both control and diseased MS, and therefore, could not be diagnosed.

SUMMARY

The frequency and type of dysrhythmias were seen equally in control and cholesterol MS. Elevated ST segment, indicative of myocardial ischemia, was seen only in the cholesterol MS and was positively related with histopathologic coronary stenosis, and to a lesser degree with Tc-99m perfusion scans. The MS has proved to be an excellent model for diet-induced CAD, as well as an excellent model for $+G_z$-induced myocardial ischemia in the diseased animal. However, the rapid development of moderate-to-severe CAD in this study, and the unexpected early animal deaths, did not provide adequate data to evaluate the ischemic response to minimal CAD. Additional MS studies are planned to identify the severity of CAD at the earliest detectable indication of ischemia during $+G_z$ and treadmill stress.